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ABSTRACT

Presented at the annual meeting of the National Association for Research in Science Teaching (NARST) in April, 1972, in Chicago, this study substantiated the feasibility of teaching science via a socio-historical approach utilizing selected concepts related to the social and historical development of science and selected concepts related to atomic energy. There was a significant increase in subject matter knowledge, and a majority of students were interested in the course. (CP)

TEACHING SCIENCE VIA A SOCIO-HISTORICAL APPROACH

By

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INTRODUCTION

Curricula developed during the last 15 years have stressed concepts, conceptual schemes, and methods of inquiry but have tended to present science in a "social vacuum". Since the early 1950's, science education has emphasized the teaching of the products and processes of science and has almost excluded the teaching of the interrelationships of science, technology, and society. Thomas summarizes this state of affairs as follows:

> The training now given to students of the natural sciences is generally planned, consciously or unconsciously, with a view to the production of professional scientists who will spend their lives at research or teaching.
>
> ....
>
> Present-day science students have been specialists since the age of sixteen or earlier: they have very limited knowledge about the world and of the behavior of man,... they know little about real history, and are scarcely sensible of their debt to the past. (8)

The trend for the 1970's, however, is toward teaching science in a social matrix in which science-society interrelationships, societal implications, and the social responsibilities of the scientists are studied. The emphasis in science education appears to be turning from an exclusive study of products and processes toward a broader consideration of science and its activities. This change in emphasis is reflected in the following statement by Hurd:

> What is needed now is a curriculum designed to bring about an understanding of the scientific and technological enterprises and the ramifications of social integration of both. ....with a focus upon the broader perspective of scientific enlightenment embedded in a social context, we have the potential of moving school science courses from their present isolation into the "real world" of the student.
>
> .....

> A general education in the sciences should make it possible for people to appreciate the worthiness of the scientific enterprise and to use its achievements.... This means that the present science curriculum will need to be changed to provide a wider picture of science.
>
> It will require reordering the subject matter of science, placing it within a cultural context, and demonstrating more concern for human betterment. (4)

The purpose of this study was to investigate the possibility of teaching about the interrelationships of science and society as well as the products and processes of science. The study utilized a socio-historical approach similar to that used in the case history approach and goes beyond by considering societal implications as science interacts with society. A philosophical base for the socio-historical approach was set by Rabinowitch when he stated:

> .... What is required is not heaping one scientific course upon another, or stuffing existing ones with more and more subject matter.... What is needed, instead, is a careful selection of material from key areas of science, suitable for demonstration of the methods by which science approaches and explores nature, of the ways in which it arrives at its general concepts; of the types of questions it asks and types of answers it receives.
>
> .....
>
> [Science education should] provide future generations not only with a general understanding of science as such, but, most of all, with the capacity to appreciate those aspects of science which affect the future of man--the impact of science on public affairs, on the fate of our own nation and of mankind as a whole. This means that science should be taught not as a separate body of technical facts, or an autonomous system of ideas, but in relation to other disciplines that traditionally mould the attitude of growing generations toward the society and the world they will live in; history, political science, sociology ..... (7)

STATEMENT OF THE PROBLEM

The problem of the study was to determine the feasibility of teaching science via a socio-historical approach utilizing selected concepts related to the social and historical development of science and selected concepts related to the atom and atomic energy. This study was organized and conducted on the basis of the following assumptions:

1. Science and society are interrelated.
2. Interrelationships between science and society can be integrated with scientific concepts and taught in one coordinated unit.
3. There exists a segment of the high school population that will benefit from a socio-historical approach to learning.

Feasibility was determined by evaluating data accumulated by evaluation instruments specifically developed for the study. The criteria for acceptance of feasibility were:

1. There shall be a significant increase in subject matter knowledge related to
   a. science and scientists,
   b. the interrelationships of science and society, and
   c. the atom and atomic energy, possessed by students participating in the study as indicated by comparison of pretest and post-test scores.

2. There shall be a high level of student interest toward the socio-historical approach as indicated by the responses of students to an interest questionnaire.
3. There shall be, in the opinion of the students, an increase in student understanding of knowledge related to
   a. science and scientists,
   b. the interrelationships of science and society, and
   c. the atom and atomic energy as indicated by the response of the students to a questionnaire.

In order to facilitate better understanding of the study and materials used in the study the following terms are defined:

1. Science is defined as a social activity...a set of behaviors taking place in human society (2)
2. Concept is defined as a summary of the essential characteristics of a group of ideas and/or facts that epitomize important common features or factors from a larger number of ideas (6)
3. The socio-historical approach to science instruction is defined as teaching the development, in a social and historical setting, of certain selected concepts in science which have exhibited a high level of social significance. (3)
4. A societal (social) implication is a direct or implied relationship between scientific or technological development and one or more facets of society (5)

PROCEDURE

This study was divided into three parts: 1) development; 2) field testing; and 3) evaluation. A short description of the procedure follows:

Development

The materials used in this study were based upon the central theme the development of atomic energy and its social implications.

Following the selection of the central theme, concepts were selected during an extensive search of library materials. The selected concepts, related to the history of science, atomic energy, the sociology of science, etc., were divided into three categories which became the framework for the development of the teaching unit:

1. Concepts related to science and scientists.
2. Concepts related to the interrelationships of science and society.
3. Concepts related to the atom and atomic energy.

The instructional materials for the teaching unit, The Development of Atomic Energy and Its Social Implications, includes a narrative text for the student. This text is concerned with the historical development of atomic energy and its social implications, and the interrelationships of scientists and society during selected periods of history. An attempt was made to give the student a more personal rapport with the scientist and his activities by including quotations of natural scientists, science historians, and political scientists.

The sections, chapters, and general topics presented in the unit are:

SECTION I. THE DEVELOPMENT OF FAITH IN SCIENCE

Chapter I. Introduction to Nuclear Energy, Scientists, and Society.

Chapter II. The beginnings of Science.

Chapter III. Greek Science.

Chapter IV. The Eclipse of Science.

Chapter V. Rebirth of Science.

Chapter VI. 18th, 19th, and 20th Century Science.

SECTION II. EXCESS FAITH IN SCIENCE BY SOCIETY (SCIENTISM)

Chapter VII. From Radioactivity to the Neutron.

Chapter VIII. U. S. Science and Politics Merge.

Chapter IX. From the Laboratory to Alamogordo.

Chapter X. German Atom Bomb Program and the Decision to Use the Atom Bomb.

SECTION III. THE CHANGING IMAGE OF SCIENCE FROM A NATIONAL TO AN INTERNATIONAL FORCE

Chapter XI. Nuclear Energy and Society.

Chapter XII. Nuclear Energy, Science, and the Future.

To supplement the narrative text of the unit, the following were developed:

1. Photographic reproductions in the form of 2X2 slides of maps, time charts, pictures, etc., that called attention to important ideas, places, and people.
2. A teaching guide, organized by chapters, to suggest effective ways of utilizing the materials in the unit.

3. Four 16 mm motion picture films that presented topics cogent to the unit--obtained through the Atomic Energy Commission Domestic Film Library.

Field Testing

Selection of the Population

The field testing of the unit, which included four weeks of instruction and test administration (15 days of instruction and 5 days for the administration of the evaluation instruments), was carried out in two different communities. Although the original experimental design provided for a comparison of science and social science classes from the same population, the desired arrangement could not be found. Therefore, the selection of two distinct high school populations was based upon availability of schools and the willingness of teachers to cooperate.

Description of the Population

School A is located in an industrial community (1970 population about 55,000) in south central Wisconsin and includes about 1300 eleventh-grade and twelfth-grade students. The study utilized four American Problems classess--107 heterogeneously grouped twelfth-graders. School B (1250 tenth-, eleventh-, and twelfth-grade students) is located in a semi-industrial community (1970 population about 50,000) in south central Wisconsin. The classes participating in the study were four Chemistry classes (76 students) consisting of 9 tenth-grade, 62 eleventh-grade, and 5 twelfth-grade students. Table I lists the IQ characteristics of the two populations.

TABLE I - Ability of the Student as Indicated by IQ

	School A	School B
IQ Range	72-147	100-148
Mean IQ	105	122
Standard Deviation	13	12
Number of Students	107	76

Evaluation

Evaluation Instrument

A 90-item five-alternative multiple choice test was developed utilizing the selected concepts of the unit. The instrument included three subtests that consisted of items related to:

1. science and scientists;
2. the interrelationships of science and society; and
3. the atom and atomic energy.

The evaluation instrument, administered to the students as a pretest and post-test, included items from the three categories and was divided into two 45-item parts. The items making up the instrument were randomly selected from a pool of items written for the various concepts used in the unit. The evaluation instrument was checked for content validity by a group of science educators.

Student Questionnaire

The student was asked to express an opinion in regard to the teaching materials and the teaching approach used in this study. The student was asked:

1. To compare the difficulty of the unit text with other science and social science reading materials;
2. to compare his interest in the material of the unit to other science and social science reading materials;
3. to evaluate the change in his interest in science;
4. to evaluate the change in his understanding of science and scientists, science and society, and atoms and atomic energy; and
5. to identify the most interesting parts of the unit.

Analysis of Data

The data collected during the study were analyzed to determine:

1. the magnitude of the gains in student achievement in subject matter knowledge related to
   a. science and scientists,
   b. the interrelationships of science and society, and
   c. the atom and atomic energy, as indicated by differences between pretest and post-test class mean scores.
2. the significance of the gains in achievement using the t-test for paired means (mean scores). The null hypothesis was: classes receiving instruction via the socio-historical approach did not perform significantly better on the post-test as indicated by a statistical comparison of pretest and post-test mean scores. Since classes were not available for a control and the unit was taught by the investigator, a conservative

criterion α = .001 was adopted for the experimental classes to maximize the likelihood that any achievement gains that might occur within the experimental classes were not attributable to chance.

3. student responses to the
   a. level of difficulty,
   b. level of interest,
   c. change in the students' interest, and
   d. change in the students' understanding of the subject matter.

4. internal consistency reliabilities (post-test) for the total and subtests using the General Item and Test Analysis Program which utilizes the Hoyt ANOVA to compute internal consistency reliabilities (1).

RESULTS

Reliabilities of the Total Test and Subtests

Table II indicates the reliabilities of the total test and subtests for both schools.

TABLE II - Internal Consistency Reliabilities (Post-test)

School	Subtest a (Science & Scientists)	Subtest b (Science & Society)	Subtest c (Atoms & Atomic Energy)	Total Test
A	.73	.75	.82	.90
B	.60	.50	.56	.78

School Mean Gains

It is noted from Table III that the achievement, as indicated by total and subtest scores, of the students from School A and School B are significant beyond the .001 level of confidence. The critical values of t with 3 df is 10.21 (α = .001) for a one-tailed test. The superiority of the Chemistry classes (School B) over the American Problems classes (School A) may be accounted for by the fact that the students in the Chemistry classes were in effect a select group.

TABLE III - Pretest and Post-test Mean Scores and Mean Gains

School A - American Problems Classes

	Pretest	Post-test	Gains	t
Subtest a	12.7	16.6	+3.9	17.0 *
Subtest b	10.0	14.6	+4.6	13.7 *
Subtest c	13.0	17.8	+4.8	27.8 *
Total test	35.7	49.0	+13.3	24.2 *

School B - Chemistry Classes

	Pretest	Post-test	Gains	t
Subtest a	15.4	21.8	+6.4	17.3 *
Subtest b	12.6	20.6	+8.0	19.3 *
Subtest c	14.6	22.4	+7.8	39.0 *
Total test	42.6	64.7	+22.1	55.3 *

* Significant at α = .001 (one-tail test). With df = 3 t = 10.2 (α = .001, one tail).

Effect of the Unit Upon Student Understanding

Note from Table IV that in School A (American Problems classes) 91% and in School B (Chemistry classes) 99% of the students expressed the opinion that the unit had increased their understanding of science and scientists. In addition, 83% of the students in School A and 99% in School B reported an increase in understanding of the interrelationships of science and society (Table V). This same positive response persists relative to gain in understanding of the atom and atomic energy; 91% of School A and 100% of School B expressed a favorable response (Table VI).

TABLE IV - Student Responses to: "What effect has this unit had on your understanding of science and scientists?"

Response	School A	School B
Increased greatly	30(29)*	37(49)
Increased somewhat	66(62)	38(50)
No improvement	7(06)	1(01)
Confused me	4(03)	0(--)

* Percentages are in parentheses.

TABLE V - Student Responses to: "What effect has this unit has on your understanding of the interrelationships of science and society?"

Respone	School A	School B
Increased greatly	17(16)	41(49)
Increased somewhat	71(67)	35(50)
No improvement	17(16)	0(--)
Confused me	2(01)	0(--)

TABLE VI - Student Responses to: "What effect has this unit had on your understanding of the atom and atomic energy?"

Response	School A	School B
Increased greatly	37(34)	54(71)
Increased somewhat	61(57)	22(29)
No improvement	8(08)	0(--)
Confused me	1(01)	0(--)

Comparison of the Unit to Other Science and Social Science Materials

When the teaching materials and strategies were ranked in terms of their interest value some variations existed within both groups; however, the rankings in both groups were essentially the same except for the assessment of the discussion of social implications-- the American Problems classes ranked it as 4 and the Chemistry classes ranked it as 1 (Table VII).

When asked to compare the reading materials prepared here with those in their other courses, a majority of students from both schools reported that the materials used in this study were easier or at least no more difficult than other science materials (Table VIII) and easier or at least no more difficult than other social science materials (Table IX).

When the frame of reference was changed to how interesting the students found the materials, a majority of both groups reported that the materials were more interesting or at least not less interesting than other science and social science materials studied (Tables X and XI).

TABLE VII - Student responses to: "Rank the following items in order of interest to you."

	Ranks	
	A	B
Scientific Explanation	3	4
History	1	2
Biographies	2	3
Quotations of Scientists	5	5
Social Implications	4	1

TABLE VIII - Student responses to: "When compared to most science materials you have read before, the reading material for this unit is:"

Response	School A	School B
Much more difficult	3(02)	0(--)
More difficult	9(08)	0(--)
About the same difficulty	14(13)	8(10)
Somewhat easier	58(55)	41(54)
Much easier	23(21)	27(35)

TABLE IX - Student responses to: "When compared to most social science materials you have read before, this reading material is:"

Response	School A	School B
Much more difficult	1(01)	0(--)
More difficult	10(09)	3(04)
About the same difficulty	46(43)	27(35)
Somewhat easier	42(39)	33(43)
Much easier	8(07)	13(17)

TABLE X - Student responses to: "When compared to other science materials, this unit is:"

Response	School A	School B
Much less interesting	2(01)	0(--)
Less interesting	10(09)	0(--)
About the same	41(39)	2(03)
More interesting	41(39)	29(38)
Much more interesting	13(12)	45(59)

TABLE XI - Student responses to: "When compared to other social science materials, this unit is:"

Response	School A	School B
Much less interesting	10(09)	0(--)
Less interesting	13(12)	2(03)
About the same	43(40)	15(20)
More interesting	28(26)	38(50)
Much more interesting	13(12)	21(27)

Student Interest in the Instructional Method

When asked what effect the unit had on their interest in science, 39% of the students of School A and 87% of the students of School B expressed the opinion that their interest in science had increased; only one student (1%) in School A reported a decrease in interest (Table XII).

Examination of Table XIII indicates a lack of agreement between the two groups of students relative to "who would benefit from this approach," however, they did agree that a population exists. It is noted that 44% of the students from School A and only 9% of the students of School B expressed the opinion that the

course should be for students interested in a career in science. The students from the Chemistry classes seemed to generally agree that all students would benefit from this kind of instruction.

A similar difference of opinion is noted in response to the question, "Would you be interested in taking a course utilizing the socio-historical approach?" As tabulated in Table XIV, 91% of the students in the Chemistry classes and only 51% of the students in American Problems classes indicate that they would enroll in the course if it were available.

TABLE XII - Student responses to: "What effect has this unit had on your interest in science?"

Response	School A	School B
Increased greatly	1(01) *	10(13)
Increased somewhat	41(38)	56(74)
No change	64(59)	10(13)
Decreased somewhat	1(01)	0(--)
Decreased greatly	0(--)	0(--)

* Percentages in parentheses.

TABLE XIII - Student responses to: "Who would benefit from science instruction utilizing this type of approach?"

Response	School A	School B
Science career students	48(44)	7(09)
Non-science career students	10(11)	7(09)
All students	48(44)	68(82)
No high school students	1(01)	0(--)

TABLE XIV - Student responses to: "If a course utilizing the socio-historical approach were offered, would you be interested in taking it?"

Response	School A	School B
Yes	54(51)	69(91)
No	53(53)	7(09)

CONCLUSIONS

The conclusions formulated here are restricted to the conditions of the study; i.e., the procedure utilized and the nature of the populations included.

Teaching science via a socio-historical approach utilizing selected concepts related to the social and historical development of science and selected concepts related to atomic energy is feasible as indicated by the following facts.

1. There was a significant increase in subject matter knowledge related to
   a. science and scientists,
   b. the interrelationships of science and society, and
   c. the atom and atomic energy, possessed by students in both schools as indicated by comparison of pre-test and post-test scores.
2. A majority of the students are interested in a course that is designed to show interrelationships of science and society.
3. A majority of the students are of the opinion that their interest in science had been maintained or increased during the study of this unit.

4. A majority of the students expressed the opinion that the reading material of the unit was
   a. more interesting than most science reading material and at least as interesting as most social science reading material, and
   b. less difficult than most reading materials in science and no more difficult than reading materials in social science.
5. A majority of students enrolled reported that the unit increased their understanding of
   a. science and scientists,
   b. the interrelationships of science and society, and
   c. the atom and atomic energy.

There is a need for additional research pertaining to the socio-historical approach to science instruction in regard to other in vitro classroom situations.

It is recommended that other central themes be identified and that these themes be used in developing units emphasizing the socio-historical approach. These units, in addition to the unit utilized in this study, should be evaluated using classes from the several high school subjects by grades (for horizontal comparison) and across grades (for vertical comparison).

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